# THE JOURNAL OF ENGINEERING EDUCATION

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## PRESIDENT A. A. POTTER.

Our very efficient and energetic President this year is Dean of the Engineering Schools, Director of the Engineering Experiment Station and of the Engineering Extension Division of Purdue University at LaFayette, Indiana.

Having acquired, no doubt from his birth in Vilna, Russia, a determination not only to become an engineer and teacher of note but also having developed that enviable American characteristic of a successful executive which enables one to develop new pioneer fields of administrative endeavor, Dean Potter has this year extended his earlier successes in Purdue University to those of a most active Presidency of the Society for the Promotion of Engineering Education.

A graduate in electrical engineering of the class of 1903 at the Massachusetts Institute of Technology with subsequent experience with the General Electric Company at both Schenectady and Lynn, he very rapidly developed those inherent qualities of a professional engineer and technical advisor which directed him through various teaching positions to that of Dean of the Division of Engineering at the Kansas State Agricultural College from 1913 to 1920.

Equally active upon the U. S. Naval Consulting Board and as District Educational Director of the Committee on Education and Special Training during the World War and as a member of many engineering and honorary professional societies, he brought to Purdue University in 1920, a most valuable initiative based upon sound fundamental training and personal experience.

During the past four years, as the result of his able direction, the Engineering Schools of Purdue University have grown in influence and in registration while the research work of the Engineering Experiment Station and its contacts throughout the State of Indiana have been most effective.

A greater stimulus, and a more conscientious and thoroughly sound directing influence could hardly have been selected to drive forward the important coördination work of this society so ably founded under the administration of Past-President C. F. Scott.

It is believed that the annual convention of the Society this year, held at the seat of both industrial activity and learning of the engineering profession, will witness the fact that great strides have been taken during the past year under the leadership of President Potter which will redound to the permanent and healthful advance of both industry and education.

## PROGRAM OF THIRTY-THIRD ANNUAL MEETING OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

UNION COLLEGE, SCHENECTADY, N. Y.,
JUNE 16–20, 1925, A. A. POTTER, PRESIDENT.
VISITS OF INSPECTION.

The different visits of inspection at the plants of the General Electric Company and the American Locomotive Company will cover the same parts of the plants. They have been so arranged for the convenience of the visitors that an inspection trip can be taken at a time which will not interfere with attendance at conferences in which members are chiefly interested.

*Tuesday, June 16, 1925.*

10:00 A.M. Visit of inspection to the General Electric Company.
2:00 P.M. Visit of inspection to the General Electric Company.
2:00 P.M. Visit of inspection to the American Locomotive Company.

*Wednesday, June 17, 1925.*

10:00 A.M. Visit of Inspection to the General Electric Company.
2:00 P.M. Visit of inspection to the General Electric Company.
2:00 P.M. Visit of inspection to the American Locomotive Company.
2:00 P.M. Visit of inspection to the Adirondack Power & Light Company, Cranesville.

*Tuesday, June 16, 1925.*

2:00 P. M. Conference on Research, Research Building, General Electric Company, A. A. Potter, President, presiding.

W. R. Whitney, Director of Research, General Electric Company;

E. H. Colpitts, in charge of the Research Laboratories, Bell System;

A. E. White, Director of Research, University of Michigan;

Milo S. Ketchum, Director, Engineering Experiment Station, University of Illinois;

George H. Burgess, Director, Bureau of Standards, Washington, D. C.;

R. A. Seaton, Director, Engineering Experiment Station, Kansas State Agricultural College;

J. B. Whitehead, Dean, Faculty of Engineering, The Johns Hopkins University;

Farley Osgood, President, American Institute of Electrical Engineers;

C. E. Skinner, Assistant Director of Engineering, Westinghouse E. & M. Company.

7:30 P.M. Meeting of the Board of Investigation and Coördination, Van Curler Hotel, Charles F. Scott, Yale University, Chairman.

*Wednesday, June 17, 1925.*

10:00 A.M. Meeting of the Division of Deans and Administrative Officers, H. S. Boardman, University of Maine, Chairman, Engineering Building, Union College.

Teaching.

Students.

(All day session.)

12:30 P.M. Conference of Teachers of Electrical Engineering, General Electric Company, H. E. Dyche, University of Pittsburgh, Chairman.

Research as an Aid to Teaching.

2:00 P.M. Conference of Teachers of English, Engineering Building, W. Otto Birk, University of Colorado, Chairman.

Plans for Coöperative Teaching of English Composition.

2:00 P.M. Conference of Teachers of Industrial Engineering, Engineering Building, J. W. Roe, New York University, Chairman.

The Extension of Education in Engineering Management to Fields Other than Factory Production. C. W. Beese, The Pennsylvania State College.

What is the Real Objective of Courses in Industrial Engineering? L. P. Alford, Editor, Management and Administration.

6:30 P.M. Dinner Meeting of the Council, Van Curler Hotel.

8:30 P.M. Meeting of the Board of Investigation and Coördination, Van Curler Hotel, Charles F. Scott, Chairman.

*Thursday, June 18, 1925.*

7:30 A.M. Breakfast Meeting of the Council, Van Curler Hotel.

10:00 A.M. Opening Session, Union College Chapel or Gymnasium, A. A. Potter, President, presiding.

Address of Welcome, Charles A. Richmond, President, Union College.

Response to Address of Welcome. A. A. Potter, President of the Society and Dean, Schools of Engineering, Purdue University.

Report of the Board of Investigation and Coördination, Charles F. Scott, Chairman.

W. E. Wickenden, Director of Investigations,

H. P. Hammond, Associate Director.

R. L. Sackett, Chairman, Committee on Engineering Students and Graduates;

H. H. Jordan, Chairman, Committee on Admissions and Eliminations;

Harold Pender, Chairman, Committee on Services and Facilities of the Engineering Colleges;

C. H. Warren, Chairman, Committee on Teaching Personnel;

W. C. John, United States Bureau of Education;

A. C. Jewett, National Industrial Conference Board.
(All day meeting devoted to this subject.)
Appointment of Committees.

12:30 P.M. Luncheon Meeting of the Council, Van Curler Hotel.

2:00 P.M. Second Session, Union College Chapel or Gymnasium, A. A. Potter, President, presiding.
Discussion of the Report of the Board of Investigation and Coördination.
Report of the Treasurer.
Report of the Secretary.

7:00 P.M. Complimentary Alumni Dinner in Union College Gymnasium, at which local alumni groups will meet with visiting teachers from their respective colleges.

8:30 P.M. Round table, Union College Gymnasium.

*Friday, June 19, 1925.*

7:30 A.M. Breakfast Meeting of the Board of Investigation and Coördination, Charles F. Scott, Chairman, Van Curler Hotel.

9:30 A.M. Meeting of the Institutional Delegates, Engineering Building, George B. Pegram, Columbia University, Chairman.

10:30 A.M. Third Session, Union College Chapel or Gymnasium, A. A. Potter, President, presiding.
The Relation of Engineering Education to Industry.
Sam A. Lewisohn, Adolph Lewisohn & Sons, New York City;
Ira N. Hollis, President, Worcester Polytechnic Institute;
F. C. Pratt, Vice President, General Electric Company;
Chas. S. Howe, President, Case School of Applied Science;
A. I. Lipetz, Consulting Engineer, American Locomotive Company.

Discussion.

Report of the Nominating Committee.

12:30 P.M. Luncheon Meeting of the Council, Van Curler Hotel.

2:30 P.M. Fourth Session, Union College Chapel or Gymnasium, B. S. King, Vice President of the Society, presiding.

Junior Colleges.

George F. Zook, Assistant to the Commissioner, United States Bureau of Education;

LeRoy W. Clark, Professor of Mechanics, Rensselaer Polytechnic Institute;

Wm. T. Magruder, Professor of Mechanical Engineering, The Ohio State University.

3:30 P.M. Reports of the Conferences held during the meeting.

Reports of Committees.

4:30 P.M. Reception to Ladies.

7:00 P.M. Annual Dinner, Van Curler Hotel, George B. Pegram, Vice-President of the Society, presiding.

Presidential Address: The Engineering College—Its Opportunity for Service. A. A. Potter, Dean, Schools of Engineering, Purdue University, President of the Society.

*Saturday, June 20, 1925.*

7:30 A.M. Breakfast and Round Table Conference on English, Mont Scott A. Herberger, Chairman.

Freshman English Courses: A Survey of the Present Situation.

All day excursion to Lake George, including a steamer trip on the Lake.

Arrangements will be made at Lake George for a meeting of the Board of Investigation and Coordination on the steamer.

## Registration and Information.

Registration and Headquarters for the convention will be in the Engineering Building, Union College.

Union College may be reached from the Union Station or Hotel Van Curler by going one block north to Union street and east on Union street to the College Gate; or by trolley on the Union Ave., Rosedale Rd., or Grand Boulevard lines going east on State street.

Rooms in dormitory, rooming houses and private families near the campus:

### Rooms.

*Van Curler.*

| | |
|---|---|
| Single room, with bath | $3.00–$6.00 |
| Double room, with bath | 5.00– 8.00 |
| Single room, without bath | 2.50– 3.00 |
| Double room, without bath | 4.00 |

*Mohawk.*

| | |
|---|---|
| Single room, with bath | $2.50–$4.00 |
| Double room, with bath | 5.00– 7.00 |
| Single room, without bath | 2.00– 3.00 |
| Double room, without bath | 4.00– 6.00 |

Rooms in fraternity houses, rooming houses and private families, near the campus: Average rate per day, $1.00 to $3.00.

### Meals.

Meals on or near the campus, approximately $1.00 each.

*Van Curler:*

| Breakfast | Luncheon | Dinner | Sunday |
|---|---|---|---|
| $.40–$.75 | $.75–$.90 | $1.50 | $1.75 |

*Mohawk:*

| Breakfast | Luncheon | Dinner | Sunday |
|---|---|---|---|
| $.50–$.75 | $.75 | $1.25 | |

Annual Dinner.....$3.00

Dinner on Lake George Steamer.....1.50

## General.

In order to assist visitors to secure proper train accomodations on their departure, the local committee desires approximate information as to the number who are leaving on each day. Definite reservations may be made at the Registration Headquarters after arrival.

Camping sites will be provided for automobilists who desire them during the convention.

## Meeting Place.

All meetings will be held on day-light saving time.

Research Conferences will be held in the Research Building, General Electric Company.

General meetings of the Society will be held in either the Union College Chapel or the Gymnasium.

Meetings of the Council will be held at the Van Curler Hotel.

Committee meetings and conferences will be held in the Engineering Building.

Ladies' rest rooms, Silliman Hall, Union College.

## Entertainment.

While the convention is in session, the Ladies' Committee will provide automobile trips, teas, and other entertainment for visiting ladies. A program will be furnished at the time of registration.

While the convention is in session, the Children's Committee will provide entertainment for the children visitors.

Mail should be addressed to the S. P. E. E. Headquarters, care of Professor F. P. McKibben, Union College, Schenectady, N. Y.

All inquiries regarding registration, room reservation, and all correspondence should be sent to Professor F. P. McKibben, Chairman of the Local Committee, General Engineering Building, Union College, Schenectady, N. Y.

Golf links are available. Guests should bring their clubs. Tennis courts are also available on the College campus.

The complimentary alumni dinner in the Union College Gymnasium on Thursday at 7:00 P. M., will be in the nature of a reunion of college alumni with their former teachers. Local alumni clubs will arrange for tables for dinner in groups. College songs and yells and other entertainment will follow the dinner.

Representatives of the Reception Committee will meet trains at the Union Station, Schenectady. Delegates who arrive in Schenectady by auto or trolley should report to the Registration Headquarters, Engineering Building, Union College.

Schenectady is located in a region of wonderful scenic beauty. Auto trips may be made to either the Adirondack or Catskill Mountains of New York, the Berkshire Hills of Massachusetts, or the Green Mountains of Vermont in half a day, or, at most, a full day. The Information Committee of Registration Headquarters will be glad to advise visitors regarding these trips.

For the excursion to Lake George, Saturday, June 20th, a special train and steamer have been engaged. The train will leave Schenectady at 9:30 A.M., and return arrive in Schenectady at approximately 7:00 P.M. The steamer trip on the Lake will provide 5 hours of unusual enjoyment for lovers of the beautiful in nature. Lake George is not only famous as one of the most beautiful lakes in the world but also around it cluster many historic events and traditions connected with the early days of our country. All visitors should plan to make this trip. The transportation charge, including the railroad trip of 100 miles and the 50-mile sail, is $2.75. A good table-d'hote dinner will be provided on the steamer for $1.50. Tickets for the trip will be sold at the Registration Headquarters.

LOCAL COMMITTEES.

Registration: L. L. Park, Chairman, E. W. Beyer.

Meetings: M. F. Sayre, Chairman, R. E. Doherty, H. F. Dewey, C. F. F. Garis.

Information: R. E. Rugen, Chairman, Miss A. Reeve, C. S. Roys, W. C. Taylor.

Housing: H. A. Schauffler, Chairman, Miss Esther Ely, B. H. Bonnar, M. M. Boring.

Reception: F. A. Wilson, Chairman, John MacDonald, W. M. Nelson.

Transportation: V. Starzenski, Chairman, E. H. Van DeBogert, B. H. Bonnar.

Entertainment: E. W. Beyer, Chairman, H. A. Schauffler, L. W. Shugg, B. L. Newkirk, J. K. Lenke.

Children: Mrs. C. F. F. Garis, Chairman, H. F. Shepherd, Mrs. E. W. Beyer, Mrs. H. F. Dewey.

Finance: F. P. McKibben, Chairman, G. H. Pfeif, C. F. F. Garis.

Ladies: Mrs. F. P. McKibben, Chairman, Mrs. C. F. F. Garis, Mrs. J. MacDonald, Mrs. M. F. Sayre, Mrs. H. A. Schauffler, Mrs. W. C. Taylor.

Publicity: F. H. Gale, Chairman, B. H. Bonnar, E. W. Erdman, L. W. Shugg.

## THE GENERAL ELECTRIC COMPANY.

The General Electric Company was incorporated in 1892, acquiring at its formation all the capital stock of the Edison General Electric Company of the Thomson-Houston Electric Company, and of the Thomson-Houston International Electric Company. The previous twelve years in the history of electrical industries was an era of invention and preparation; incandescent and arc lighting and electric traction were growing arts, but were so clouded and delayed up to 1892 by the clash of divergent methods that only a few realized their vast future utility.

Never in the industrial world did organization effect a more magical change in releasing pent energy. Guided by master hands, electrical arts leaped into industrial preeminence; volume of manufacture of appliances, progress of invention, public confidence in electricity and its general utilization, all took long strides forward. The development of electrical arts, not only in the United States but throughout the civilized world, became the history of the General Electric Company.

Offices of the General Electric Company have been established in the principal cities of this country and in many foreign countries. It has important manufacturing plants located at Schenectady, N. Y., Lynn and Pittsfield, Mass., Harrison, Watsessing and Newark, N. J., Erie and Philadelphia, Pa., Fort Wayne Ind., Cleveland, Ohio, Bridgeport, Conn., and lesser plants at many other points. The total land area of these works is 2,058 acres; the total floor space of the buildings about 25,337,000 square feet. The total number of persons in the employ of the Company exceeds 75,000.

## ENGINEERING AT UNION COLLEGE.

BY FRANK P. McKIBBEN,

Professor of Civil Engineering, Union College, Schenectady, N. Y.

Union College has two engineering courses—civil and electrical. The former was established in 1845 and the latter in 1895.

But long before 1845, Union College had been laying the foundations for an engineering course, because as early as 1811 a course in natural philosophy was given by Professor Fred R. Hassler, who in that year left Union to establish and become Superintendent of the U. S. Coast Survey. But such a course was hardly an engineering course, nor was the scientific course, which was begun at Union in 1828, an engineering course. It lacked the essential features of technical instruction, that is, applied science.

Professor Gillespie, who became Professor of Civil Engineering in 1845, remained at his post until his death in 1868, and is well known to-day for his text books on land surveying which are still used in several colleges. Professor Gillespie received his technical education at L'École des Ponts et Chaussees and the effect of that famous French institution on the early beginning of engineering at Union is clearly shown in the course of study as outlined in the pamphlet written in 1857, which shows that surveying, drafting, descriptive geometry with some general instruction in bridge engineering and water engineering constituted the principal part of the technical training. This pamphlet of 1857 states that students were admitted to the Civil Engineering course on the same terms as to the regular college course, namely, "$19 per term for tuition, room rent, etc."

The Civil Engineering course has continued until the present time and to-day the course is divided into two options—a

technical option and an administrative option. Both of these options might be described as courses in general engineering and are further characterized by the rather unusually large percentage of time devoted to courses in economics and business administration. The writer gives a course in the theory of structural engineering to seniors and also a course in the principles of accounting as applied to corporation finance and finds the students' interest in each of these two subjects equally keen. The Civil Engineering department considers the introduction of a reasonable amount of business administrative subjects into an engineering course as highly successful and beneficial.

The course in Electrical Engineering was established at Union in 1895 and later in 1902 Dr. Charles P. Steinmetz was elected Professor of Electrical Engineering. Dr. Steinmetz was born in Breslau, Germany and received his higher education at the University of Breslau and at the Polytechnic Institute at Zurich. Dr. Ernst J. Berg succeeded Dr. Steinmetz and has been Professor of Electrical Engineering from 1913 to date. The work of the Electrical Engineering department is characterized by the extent to which mathematics is used in electrical work and further by the coöperation between the General Electric Company and Union College in that the Company permits certain graduates to come to the college one afternoon a week for two years to receive instruction under Dr. Berg leading to the degree of M. S. in Electrical Engineering. Dr. Berg has a large class of these men.

# THE EDUCATIONAL AND VOCATIONAL GUIDANCE OF ENGINEERING STUDENTS AND GRADUATES.*

BY H. P. HAMMOND.

In the investigation of engineering education which is being conducted by the Society for the Promotion of Engineering Education under a grant of funds from the Carnegie Corporation, it has been recognized that the question of *What To Teach* is not more important than *To Whom* and *By Whom* it should be taught. In other words, considerable attention is being given to the personnel aspects of engineering education. Studies of this factor are grouped under two principal heads: One relating to students and graduates, and the other to teachers of engineering. This discussion will deal with the students and graduates and will have as its principal purpose consideration of the guidance of students and the vocational guidance of graduates, although this is but one phase of the studies which are being carried out.

Data which will be quoted in the paper have been gathered through the coöperation of committees of the faculties of a representative group of institutions throughout the country. The studies have been made under the general direction of a committee of the Society of which Dean R. L. Sackett is chairman, and Mr. E. B. Roberts of the Westinghouse Electric and Manufacturing Company is secretary. Information relating to entering students has been supplied by 32 colleges, and that relating to graduates by 35 colleges. These institutions represent all of the various types which offer engineering courses and are situated in all parts of the country. I think it is fair to say that, while we have not canvassed all of

* Paper presented before the Engineering Extension Convention and Industrial Conference at the College of Engineering, The Pennsylvania State College, May 14–16, 1925.

the students or all of the graduates, we have a very fair representative sampling. Over 4,000 students and over 3,500 graduates of the classes of 1922, 1923 and 1924 are represented in the summaries.

It was the purpose in considering the problem of educational guidance of engineering students, as well as the numerous other problems of student personnel, to learn something of their racial and ancestral background, as much as possible regarding their secondary school training, something regarding their homes, and as much as possible on the questions of when, why and how they chose engineering as a life-work. The effort was also made to determine how much and what sort of advice the students received in forming this important decision. It will be appreciated that the factors to be measured were such as to make it difficult to obtain all of the information sought with satisfactory accuracy; particularly since there was little choice in the matter of methods to be used. Yet the results appear to have been reasonably satisfactory. I think it is realized by many that a considerable number of students who enter our engineering colleges do so without any clear idea of the field of work they are entering and without any knowledge of whether or not they are fitted for it. The figures on student eliminations substantiate this. It was the purpose to examine into this situation, as well as to study carefully our present methods of admission of students, and it is the hope that eventually the way may be pointed to a more valid basis for the admission of students and for the selection by the students of their course of study.

The above is by way of introduction. Some of the results obtained which bear directly or indirectly on the question stated will now be given in very condensed form.

As to racial extraction we find that 96 per cent. of engineering students are native-born and that 74 per cent. of their parents and 57 per cent. of their grandparents are native-born. 90 per cent of engineering students are of either native-born grandparents, or of grandparents born in Northern and East-

ern European countries. If these figures are significant it appears that the racial stock of our students is good. The variations from the above figures are large. One prominent engineering college, for example, has a student-body whose parents are but 40 per cent. native-born, and several having student-bodies whose grandparents are 25 per cent. or less native-born. On the other hand, there is one college, 100 per cent. of whose students are from native-born grandparents and there are many which have a ratio of 85 per cent. of native-born grandparents, or more. As a rule we find the students of the Middle Western and Southern States of native-born stock to a greater extent than those in the Eastern States. As might be expected, institutions drawing from a rural population have student-bodies of native stock to a greater extent than those drawing from the cities.

As a measure of the types of homes from which students come we have examined into the type of work, the positions, and the education of the students' parents. It is interesting to note that but 16 per cent. of the students' fathers are engaged in what are usually classed as the professions—engineering, medicine, law, and the like. 17 per cent. of the fathers are farmers, 22 per cent. are in financial or mercantile work, 29 per cent. are in the industries, and the balance—15 per cent.—are in journalism, publishing, public service and other lines of endeavor. 42 per cent. of the fathers are owners or proprietors of business, 6 per cent. are engineers, and 19 per cent.—a surprisingly high figure—are skilled or unskilled workmen. The remaining 33 per cent. are in various administrative, clerical, sales or other types of positions. The statistics of the education of the students' parents are interesting and probably significant. But 13 per cent. of the fathers are college graduates, and but 40 per cent. have graduated from high school. On the other hand, 42 per cent. of the fathers have only a grammar school education or less, and 15 per cent. have less than a complete grammar school education. The figures for the mothers are substantially the same, though

there is a smaller proportion of college graduates and a higher proportion of high school graduates. I should like to call attention particularly to these figures and to emphasize the fact that such a comparatively small proportion of parents have gone to college, or even graduated from high school. This, of course, is but an indication of the rising tide of education in our country and of the greater length of time students now remain in school as compared with those of a generation ago. Yet these facts are often overlooked in considering present problems of higher education.

If the above figures are significant, they indicate that our students, on the average, come from homes of rather limited cultural background where there is but a limited knowledge or contact with higher education and in particular of engineering education and the life and work of the engineer. Other figures to be quoted presently seem to bear this out.

As another sidelight we find that engineering students to a very large extent are obliged to assist themselves financially by working both before and after entering college. 90 per cent. of the 4,000 students reported that they had done a substantial amount of work during the year prior to entering college. They earned on the average about $417 during that year and saved $219 of their earnings. It is interesting to note the variations from these average figures among the various institutions—in fact the study of the variations from all of the figures quoted are almost as informative as the averages. In the case of one of the most prominent privately endowed Eastern universities, but 50 per cent. of the engineering students earned any money in the year prior to entering college, whereas in a number of the other institutions the proportion was 95 per cent. or more. Just about 50 per cent. of the work done was in some way connected with engineering.

As to the educational background of the students, it is found that 87 per cent. prepared for college in public high schools, and less than 7 per cent. in private prepararatory schools; the remainder having prepared either in sectarian schools,

by private tutoring or by one or more years in college. This proportion of high school students is higher than the ratio of all of the male graduates of public high schools to the number graduating from all secondary schools in the country. Apparently the graduates of preparatory schools do not enter engineering courses in very large numbers.

The average mental ability of students entering engineering courses appears to be good. Over 60 per cent. of the freshmen canvassed were either honor students or were in the upper third of their high school classes and but 2.6 per cent. were in the lowest third of their classes. The balance, or 37 per cent., were in the middle third of high school graduating classes.

If I were to summarize my impressions of the data I would say that our students appear to be bright boys of rather limited cultural background but of sound racial extraction. In other words, it appears that our material is fundamentally good, but that our task in teaching and guiding our students is by no means a simple one.

With the foregoing as a background, we can proceed to consider the matter of educational guidance.

All of the students upon which this information is based were asked to select from a rather comprehensive list the general grounds upon which they formed their decision to go to college, their decision to study engineering, and their selection of a particular engineering course. They were permitted to indicate more than one reason. Consequently the following figures are not given as percentages of the whole number of reasons given, but are the proportion of students who indicated each of the reasons. On this basis, the advice of parents was given as a reason for deciding to go to college by 32.9 per cent. of the students, advice of teachers by 10.1 per cent., and advice of others by 10.4 per cent. Since a given student might have given more than one of these, it appears that only one half or less of the students based their decision to go to college upon advice from any source. It is important to note

that only 10 per cent. of the students stated that they had reached their decision as the result of advice of teachers.

The effect of the colleges in this matter is indicated by the fact that but 9 per cent. of the students stated that the colleges themselves or anything connected therewith, such as alumni, fraternities, athletics and the like, had been factors in their decision.

The reasons indicated more often than others were the following:

"To earn a good living".....47.4 per cent. of the students
"For general self-improvement or to obtain a higher education".....58.2 per cent. of the students
"To become an engineer".....41.6 per cent. of the students

The decision to go college and to study engineering was reached at quite an early date—50.2 per cent. of the decisions having been formed before the students entered the last year of high school, and 76.9 per cent. of them either in the last year of high school or prior thereto. This is mentioned in order to indicate that educational guidance of prospective engineering students can not be delayed until late in the high school course, as is now generally the case with many of the steps being taken by the engineering colleges.

When we turn to the basis of the students' decision to study engineering, we find the advice factor still smaller. But 13.6 per cent. of the students indicated that their parents had had any weight in the matter and but 4.8 per cent. that they had been influenced by the advice of teachers.

I may pause here long enough to say that my knowledge of students and their reactions convinces me that they have given honest answers to the questions and that the figures are substantially correct.

The decision to study engineering was apparently reached on the definite appeal of engineering work, a supposed aptitude for engineering, the belief that engineering would enable them to earn a good living, or the belief that the study of engineering would form a good preparation for almost any line of

endeavor. It is interesting to note that about one fourth of the students gave the latter as a reason for the selection of an engineering course.

In the selection of a particular course in engineering the advice factor is so small as to be almost negligible. But 10.6 per cent. of the freshmen indicated that any advice whatever, whether of parents, teachers, or friends, was of any moment in their important decision to become a civil, electrical, mechanical, or other sort of engineer. The principal reasons for the choice of a particular course of study are a definite interest in the line of work—this reason having been given by 65.9 per cent. of the students. The influence of work done in the particular field was stated in 18 per cent. of the cases. Supposed good opportunities in the field was given as a reason by 19.7 per cent. of the students. 8.8 per cent. of them confessed that they made their choice on perfectly haphazard grounds.

As some measure of the understanding of the students in choosing engineering and their particular course in engineering as a life-work, we asked these 4,000 young men to write a concise and clear statement of their conception of the field of engineering which they proposed to study. These papers were submitted early in the freshman year. They were read by members of the faculties and graded under four headings: Little or No Conception, Poor Conception, Good Conception, and Excellent Conception. The results were as follows: Little or None—18.7 per cent., Poor—37.9 per cent., Good—30.5 per cent., Excellent—12.9 per cent. It is to be noted that the total of answers showing little or no conception or a poor conception was 56.6 per cent. It must be understood that these ratings are not on any absolute scale, but are merely given as the opinions of the teachers to whom the papers were submitted. Since the papers were read by a great many teachers it seems fair to assume that they have reasonably well rated, on the average, and that the results are a fair indication of the matter we are endeavoring to measure.

The variations in the ratings in the different schools are

quite wide. In some schools a majority of the students apparently show a very fair idea of engineering work and of their chosen field in engineering. In these schools it is usually found that there is a definite effort made by the faculty by means of orientation courses or the like to give the students an idea of engineering work early in the course. In other schools where no such effort is made the students usually show a lack of this conception.

To summarize: Apparently engineering students form their decision to go to college, to study engineering, and to take a particular course at an early date—a majority long before they have completed their high school course. The decisions appear to be based to a very large extent upon voluntary selection and to be little influenced by advice of parents or teachers. The decisions to study engineering seem to be based to a very considerable extent upon incomplete or unsubstantial knowledge. These inferences are, I think, reflected in the very large shrinkage in the enrollment in engineering schools during the first two years. Of each 100 entering students, but 62 successfully complete the first year and proceed with their class, and but 42 successfully complete the first two years. The others drop out of college for one reason or another; the predominant reason being scholastic failure. A much smaller percentage of student eliminations are due to health, financial, or other causes than sometimes supposed. The predominant causes of scholastic failure are poor preparation, lack of ability, lack of interest in the work, and failure to adjust to the requirements of engineering courses. To these might be added poor teaching and failure to arouse and hold the interest of the students in their work during the early part of their course. In no other branch of what may be called "Vocational Courses" in higher education—in which the professional courses are included is there such a high mortality as in engineering. At present about 37.5 per cent. of students who enter engineering courses graduate from them, while the percentages in other courses are about as follows, as found by

canvassing a number of colleges offering the courses stated: Medicine—75 per cent., Law—60 per cent., Dentistry—60 per cent., Agriculture—55 per cent., Business Administration—55 per cent.

There seems to be a very great need and opportunity for the dissemination among high school boys of accurate and comprehensive information regarding engineering and the life-work of the engineer. It appears that this should be done early in the high school course, and not delayed until the latter part of the last year, as is common at present. From other studies which we have made, it also appears that there is great need for the dissemination among high school students and among high school teachers and principals, of accurate information regarding the requirements for admission to engineering courses, and the curricula and requirements of engineering courses themselves. Though our high schools at present usually offer all of the subjects required for admission to engineering courses, yet one student in five entering engineering courses from high school cannot meet the specific requirements for admission—and they are not severe, although they almost never lack the required total number of units. Many of the engineering colleges are making some efforts in these directions—either by distributing literature regarding engineering courses and the work of the engineer, or by personal letters to high school seniors, or through visits to the schools by officials of the college. We have examined a great deal of literature of this sort. Some of it is excellent and if it reaches the high school student early enough in his courses should be of great help to him in choosing a college and a course of study. For the most part, however, these efforts are confined to the students in their senior year, and too little of it is directed toward informing high school teachers and principals in order that they may be in a position to give accurate and sound advice. I do not mean to imply by these remarks that the engineering colleges should engage in wholesale propaganda to attract more boys to engineering courses,

but I do believe strongly that there is need for us to coöperate more effectively with the high schools, and I cannot state too strongly that I think we should endeavor to concentrate our engineering educational work on what may be termed "the good risks." Engineering education is costing the people of this country in the neighborhood of $30,000,000 per year, and over and above this it is costing the efforts of a great body of conscientious teachers and college authorities, and it is costing a fraction of the lives of some 55,000 or 60,000 young men per year—the latter possibly the most valuable investment of the three—and it would seem that we should make every effort to have our work done for those who are able to profit by it in reasonable measure. To me it seems high time that we gave much more attention to the important question of the rational selection of student personnel and to effective means of directing to engineering courses those who possess the qualities needed successfully to pursue those courses.

Just what means may be used more effectively to guide high school boys can not be determined in any offhand way. We can make a start in the desired direction, however, by the dissemination of information—and this I believe should be done. I do not think it is a proper part of our American philosophy to hamper the freedom of individual choice but I see no reason why our educational philosophy should deter us from offering guidance to a reasonable degree to those who are to be the beneficiaries of our system of public instruction and of higher education. To disseminate adequately information regarding college courses among high school students and teachers might seem to be a very large undertaking, yet when it is realized that over 50 per cent. of engineering students have their homes within 107 miles of the institutions which they attend it does not seem so difficult. Whatever will bring the teachers of the colleges and of the high schools into closer contact so that they may have a mutual appreciation of each other's problems will, I am sure, be mutually profitable. I think we have done far too little in this direction in the past.

Now to consider the graduates and their vocational guidance: The figures to be quoted were obtained by means of questionnaires sent to the graduates of the classes of 1922, 1923, and 1924 of a representative group of 35 institutions situated in all parts of the country. Approximately 55 per cent. of the graduates returned replies to the questionnaires, so that the results are probably reasonably representative of the entire group of graduates of the engineering colleges for the years stated. On many of the questions submitted the answers are probably sufficiently representative to warrant drawing conclusions.

The distribution of the graduates among positions of various kinds in as follows: Administrative—8.8 per cent., Clerical—5.5 per cent., Technical Engineering, including construction, consulting engineering, design, estimating, testing, drafting, and operation and maintenance—60.0 per cent., Research (also properly included in Technical Engineering)—7.5 per cent., Sales—6.4 per cent., Teaching—3.9 per cent., Manual Work—2.1 per cent., and all other kinds—6.0 per cent., To summarize—60 per cent. are in technical engineering work, 11.4 per cent. in research and teaching. 15.2 per cent. in administrative and sales work, 7.6 per cent. in clerical or manual work, and 6.0 per cent. in miscellaneous types of work.

These positions were obtained in the following manners: Through a teacher or other official of the colleges—24.8 per cent., through the solicitation of an employer—22.4 per cent. through work done prior to graduation—15.7 per cent., through personal solicitation of employers by the graduates—14.3 per cent., through family connections—7.5 per cent., through the alumni of the colleges—6.6 per cent., through advertisements or employment agencies—5.9 per cent., and by other means—2.7 per cent. It will be noticed that 47.0 per cent. of the graduates obtained their first positions through the efforts of the colleges or of employers; the others obtained them through their individual efforts.

The reasons given by the graduates for their choice of first

positions are as follows: Because the work was in the direct line of their college course or closely associated therewith—48.3 per cent., Apparent good opportunities—25.2 per cent., Only job available—9.9 per cent., Desired location—9.3 per cent., Good salary—4.0 per cent., and other reasons—3.3 per cent. It is apparent that the desire for the right sort of experience or of opportunity was of far more influence than all other factors put together, being 73.5 per cent. of the total, and that salary and location were, ostensibly at least, minor factors. It would also appear that few students were obliged to take positions because of poor opportunities to choose since but 10 per cent. stated that they accepted the only job available. Probably there were more graduates to whom actually only one position was available, but at least it appears that sheer necessity did not cause its selection.

The above relates the first positions held. It is found that there is a very considerable shifting about from job to job, or turnover, among the recent graduates. 56.5 per cent. of the graduates of 1922 have held two or more positions since graduation, and 24.0 per cent of these have held three or more positions. 39.1 per cent of the class of 1923 similarly held two or more positions, and 12 per cent. held three or more. Even in a class graduating as recently as 1924, about one quarter of the class have held two or more positions since graduation. Apparently a great number of graduates either find themselves in positions to which they are not suited, or fail to find the position which offers them the type of experience or work which they desire. Of course there is the added group who take positions of a temporary nature or are forced to find new employment when a given job is finished. The number of these cannot be determined, but I rather think it is small. I do not mean to say that a certain amount of travelling about and changing work is not in some ways desirable, but it must also be remembered that a good deal of this undoubtedly results in loss of valuable time in becoming established permanently in a career.

It has always seemed to me, and I think the figures confirm the belief, that there is an unnecessarily great deal of fitting of square pegs into round holes in our educational work—and particularly in engineering education. It occurs all along the line, from before admission to after graduation. How much of our efforts as teachers is spent in attempting to train young men, of ample ability along some lines, to become engineers when they evince less than the requisite amount of aptitude, inclination or interest in engineering work! And how many cases we see of graduates placed in positions for which they are altogether unsuited while they migh fit admirably into some other niche where they would be successful and happy! How much can we do to overcome these conditions? More, I think, than we have been doing. Some of our institutions have indeed made an excellent start in the proper direction through the introduction of personnel systems and the selection of personnel advisers, either from among the faculty or individuals specially designated for the work. Other efforts have taken the direction of lectures to the graduates by members of the staff and by men brought in from the outside, the purpose of the lectures being to give the prospective graduates reliable information as to the various lines of work they may follow, facts about the field of engineering work in general, and suggestions in the choice of position and career. These efforts are all to the good and should be extended. But we have not much more than made a start and the field seems to be entirely open for anyone who has practicable working plans or suggestions to bring forth. One word of caution may be given. Whatever we do, we should not, I think, give our graduates the impression that society in general, or the field of engineering, or the colleges, or employers, owe them a place in the world which they should be able to step into without much effort and which leads without undue exertion to the rewards they think should be theirs. On the countrary, I believe that the graduates should be impressed with the fact that they have a very definite debt to society—that they are

the beneficiaries of an educational system founded upon a most liberal philosophy—and that they must exert themselves to the utmost to repay something of that debt. Furthermore, I believe that they should be impressed with the fact that it is strictly and entirely up to their own efforts to achieve a place in the world. This does not mean that we should not assist them to find the work for which they are best suited, far from it. I believe that we should do all that we can to correct this fitting of round pegs into square holes; but having pointed the young man in the right direction, I think we should impress him with the notion that it is up to him to get under way and to continue in motion.

There is one further element of our studies which I should mention. It is that relating to study or the continuation of education among the graduates. In order to get some light on this matter the recent graduates were asked to give answers to a number of questions as to the amount and kind of studying done since graduation and the manner in which they have done it. We find the following facts: 76.8 per cent. of the positions occupied are such as to require study, while 23.2 per cent. are not. Of those requiring study, 66.7 per cent. are such as to require the student to continue along the specific or general lines of the college course. Approximately one third of the studying is done under the supervision or direction of employers, while two thirds of it is not. In two thirds of the cases of positions which did not require study, the graduates have nevertheless continued more or less systematic pursuit of some line of study. About 55.3 per cent. of our graduates have continued their interest in and the study of cultural subjects including literature, art, psychology, sociology and the like. Asked as to the value, in their opinion, of the cultural work taken in college, only 13.5 per cent. of the graduates stated that they considered the value of such work to be negligible or not worth the time spent upon it, 30 per cent. considered it to have been worth the time spent, and 56.5 per cent. considered the value of such studies to have been "con-

siderable" or actually "indispensable to their intellectual development." These indications of the continued efforts of our graduates to develop and educate themselves are very encouraging. They are also, I hope, an indication of the fact that college graduates feel that their college courses have given them but the essential elements or the foundation upon which they themselves must erect a superstructure of knowledge and skills.

One wonders, however, whether or not this study has been well directed or if the time and energy expended has been placed to the best advantage. There are many evidences of an awakening realization among employers of large numbers of engineering graduates of the opportunities of developing useful men in part, at least, through carefully planned and directed study and educational work. It is to be hoped that this movement will be extended—not with the purpose of exploiting the graduates for the benefit of the concerns without a proper and proportionate consideration of the futures of the young men and their development in a broad way—but for the mutual benefit of the young men and the companies. Judging by the familiar examples of a few of the larger concerns, it appears that the policies in these matters are for the most part wise and broad.

I am not sure, however, that the colleges themselves have recognized the opportunities in this matter of the continued education of their graduates. The clinic of the medical school is the college-operated hospital or one in close contact with it. The young interne gets his clinical experience under the direct guidance of many of those who taught him before he completed his medical course. The clinic of engineering is in industry itself—using the word industry in its broad sense—and the young engineer serves his novitiate under the most widely varying conditions, with no guidance from the institution in which he obtained his fundamental training. There is much discussion of lengthening the engineering course to five years, or even to six, but there are many who question whether more

than four years of undergraduate work in engineering is justifiable for the general run of engineering students. Assuming that the engineering courses are to continue on a four-year basis for the majority of students, what provision can be made to guide the educational work which they must or should pursue before they can properly assume the title of Engineer or rightly consider that they are well-educated men? I think that our institutions have a distinct and untouched field in this matter and that the extension divisions which are being inaugurated in so many of the tax-supported colleges might well give their attention to this possibility of the extension of the education field.

My general purpose in presenting this paper was to bring out my belief that the work of the colleges could be done to better advantage if more systematic effort were given to certain activities in addition to the regular work of instruction. This, of course, is not new. We all appreciate that we could do better work with better students, though I fear that we often fail to recognize the opportunities for directing to engineering and admitting our students by more valid means than we use at present. And I also believe that our work would be more fruitful if the colleges and employers mutually undertook more systematic methods of assisting graduates in the choice of positions and in guiding them in the continuation of their education.

# ENGINEERING–STUDENT RAW MATERIAL AS COMPARED WITH THAT OF TEN YEARS AGO.*

BY WM. T. MAGRUDER,

Professor of Mechanical Engineering, The Ohio State University.

Comparisons are nothing new, either in history, engineering, or parlor talk. I sometimes wonder if General Washington and President Lincoln would recognize themselves if they should hear the eulogistic speeches which annually in February are used to keep alive, or kindle, the fires of patriotism in Americans who have received, or are supposed to be getting, a typical American education. One by one Mr. Washington's little child-like actions which used to prove that he was human are being swept aside in an annual flood of oratory. I am expecting someone to show that hatchets were not invented until after the Battle of Yorktown, that cherry trees are the twentieth century invention of Mr. Burbank, and that Mr. Lincoln's face, once described as one of "rugged homeliness", was really one of "rugged beauty". It is equally true that "distance lends enchantment to the view", and that "time softens all the asperities of life". To come closer home, is it really true that our forbears were all saints and our children are all sinners? Were there not flappers and sheiks fifty years ago, even if they were not called by those names? Surely the artist-painters of a generation or two ago portrayed people as they saw them. Is it only our generation which has always been right while the ones before ours and the present one are just plain bad?

In applying our mental yardstick in the measuring of the results of psychological tests now, as compared with those taken ten years ago, we should be careful to see that we are fair and judicial in our measurements and conclusions, that

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we do not take too much for granted, do not decide hastily, and are sure that we have all the facts before we draw any conclusions.

What then are the facts on this subject?

1. Comparatively few persons who are now teaching engineering students were doing so in 1914, hence the number of possible judges is not large.

2. There is no doubt but what a higher standard is set for the passing grade at present than was the case in 1914, both in the schools and in the colleges.

3. Because of the greater number of high schools which are now graded as "accredited", there are greater variations in the product of these schools. We are therefore getting more of the poorly prepared scholars as well as more of the much better prepared scholars than we did in 1914.

4. My colleague, Prof. S. E. Rasor, mathematics, calls attention to the fact that the time was when only the selected student went to college. He had a definite purpose in view, and that was the preparation of himself for a life of culture and refinement in one of the learned professions, such as law, medicine, or the ministry, and possibly engineering. It is the old story of the masons who when asked what they were doing, one replied that he was getting $10 a day, one said that he was cutting stones according to the boss's orders, while the other said that he was building a cathedral. So to-day, young people are coming to college to have a good time, to make acquaintances who will help them to climb socially and financially, to learn how to do some few things for which some one will pay them a wage, to get an education, to learn how to enjoy a life of culture and refinement, or, to be of the greatest service to their fellow man. To-day, the average student does not seem to take his studies or his opportunities seriously. Continued faithfulness for all the weeks of a term seems more rare than it used to be, possibly because the opposite is more advertised. Prof. Thorndike reasons that "the cream of our population goes to college now as formerly; but, with the

influx into our colleges and universities of a larger and larger number of more poorly prepared students, both in actual preparation and in ability, we are surely getting a larger and larger body of students with a constantly diminishing preparation and ability to do college work". Statistics and observations seem to confirm this point of view. Prof. H. A. Toops, of our Department of Psychology, says that, "Taking the country as a whole, it is rather certain that we are getting a higher proportion of weak intellects than the colleges took ten years ago. As a result of this progressive deterioration in the average quality of the intellects of the entering students, we have had in this country in the past ten years a tremendous growth of specialized colleges which cater to students weaker than those capable of mastering standard disciplines."

5. As to the remedy for this state of affairs, it lies in stricter entrance requirements, in fact, as well as on paper; in instructors thinking more of the reputation of the institution and that of its alumni than of the student who wants to be reinstated after wasting his time and his father's money; in dealing in justice rather than in sympathy; in differentiating the professional engineering courses from those which are largely trade courses; and by having more vocational curricula for those who desire to become artisans. Are we as citizens doing patriotic work by trying to ram a lot of embryo mechanics through the professional filter-press before they have proven their right, by mastering a trade or by otherwise proving their ability, to demand that public or private money should be spent on them? Are we not making two-thirds of college entrants unhappy and sour when we, or some one else, might be of service to them? Why treat all kinds of lumber as though they were all mahogany or boxwood? They have their uses; and so have the pines. Yes, and scrub-pine at that; but not for pianos and high-grade furniture.

6. Variations in the standards used in teaching different high-school subjects, the substitution of electives and options for the required studies, the attitude of some high-school prin-

cipals and teachers that it is not the business of the high-school to prepare its students for college, and the practice of certain high-schools of graduating such a per cent. as is desired by the Board of Education and the parents whether the average grade of the class is sixty per cent., or twenty-five per cent. as in one case, are other causes why the raw material of the engineering college to-day differs from that received ten years ago. Young people used to be made to study subjects even if they were thought to be "hard". It was the intellectual and mental and moral disciplines inculcated which made the study valuable, rather than the commercial value of the knowledge or skill acquired. We have gone from the three R's of our great grandfathers to the forty dabs of knowledge which now are included in a common-school education. Even mathematics and the power to analyze, and the ability to make arithmetical calculations, and to count your change are tabooed in some schools of the middle west, because "They are hard". Now, many young people are made to study no subjects except those that they *think* they will like. Are not some of our young people being fed solely on pop, candies and sundaes? The use even of fruits is not now good form; they should be served as juices, and so save the trouble of mastication.

7. Variations in the standards of the teaching force cause many a student to be passed by an instructor of freshmen who himself was graduated only a year or two ago. However, it should be said that many a young instructor is more just in his marking of his students than are many of the older professors who do not give the same time and thought to such details.

8. Variations in the meanings of the grades now given with those given ten years ago cause comparisons to be possibly unfair. It is well known that many instructors can not use the decimal system of grading. They are academic impressionists. Even with the best of us, who desire to be fair and just, does a passing mark mean the same as it did with us ten years ago?

9. With larger classes in high-school and college subjects, the average student does not get the same amount or quality of instruction that he did when classes were smaller, and therefore he is passed on when he should have been failed with the result that the latter work of that student is worse than the former.

10. Many of us might be willing to confess privately that we are not covering as much of the text as we used to cover, because either of the inertia and dense ignorance of the class, or our inability to get the instruction to the student. Our old demonstrations no longer carry the same logical power and conclusiveness to the student. Lack of training in logic, and analysis, and reasoning are the bare spots which cause his rough-sledding and hard-going.

11. On the other hand, are we not trying to put into the same old quart cup that we used ten years ago the same old quart of formal knowledge and also all the gallons of the increments of knowledge that have been accumulating since that time, and all in the same allowance of time to the students? We have been adding courses, and subjects, and new chapters, but has any one been known to give up any of those precious subjects that he has worked over so hard for all these years? Have any of you teachers really made a study and comparison of the actual contents of the courses that you are giving with what your copy of the text-book that you used as a student shows that you covered? Try it once, and then give honor to the student who absorbs two quarts of the gallon of knowledge that you throw at him while remembering that you absorbed only a gill of the quart that was thrown at you, when you were a student. I do hope that each of us will take this matter very seriously to heart and mind.

12. Again, I am informed by the secretary of our Entrance Board that during the last two years the certificates presented for entrance to the College of Engineering have included more subjects of college preparatory character than heretofore. Also, that high-school principals and teachers are advising their pupils more and more as to the requirements for admis-

sion to the engineering schools. Gradually the fact is becoming known that entrance to a College of Engineering requires a specific amount and kind of knowledge rather than a smattering of many subjects, and that an engineering student must have studied mathematics in the high school, even if his chum is allowed to graduate without having studied either algebra or geometry.

13. We occasionally hear invectives against present-day extra-collegiate activities, as though college students of ten, or twenty, or forty years ago indulged in none of these things. While the kinds of temptations to waste time during college life have changed, yet the amount per capita of time so wasted is probably no greater than it used to be.

14. The secretary of our Entrance Board reports that there were twelve conditions in physics in 1920 and twenty-five in 1924, while there were forty-five conditions in solid geometry in 1920 and thirty-three in 1924.

15. Prof. J. H. Weaver, of our Department of Mathematics, reports that of 347 students who took Freshman mathematics in 1913, sixty failed it; of the 339 who took the subject in 1914, fifty failed it; of the 442 students who took Freshman mathematics in 1923, ninety-six were segregated to preparatory mathematics No. 400 because of their low standing in a very simple test given two weeks after college opened in the autumn, and that of the remaining 346, sixty-two were failed at the end of the Autumn Quarter. The figures for 1924 are 114 remanded to the preparatory class, and of the balance of 374, eighty-seven were failed last December. This shows that there were twice as many sub-freshmen in 1924 as were failed in 1913 or 1914. As the ground covered is thought to be less, either our teaching is not as good, or the quality of the preparation is decidedly poorer now than it was in 1913 and '14.

16. Another statistical fact that seems to show that either the quality of our raw material is poorer now than it was ten years ago, or that our teaching is less efficient, or that we rush the students too fast, or that we require a higher standard of student proficiency than we did ten years ago is found in the

statistics of the mortality of engineering colleges. At many institutions there has been an increase in the student mortality since the war. For example, at one engineering college, the report of the president shows that the mortality has ranged from a minimum of thirty-one to a normal maximum of ninety-one per cent. in the last fifty years, and these figures are quite extreme and unusual; that the mortality of the post-war classes, counting all persons who have been graduated who were once members of that particular class as compared with the number of entrants four years previously, has varied as follows: the class of 1919 graduated 51.8 per cent.; the class of 1920 graduated 53.9 per cent.; the class of 1921 graduated 57.1 per cent.; the class of 1922 graduated 46.4 per cent.; the class of 1923 graduated 35.3 per cent. eventually although only 30.5 per cent. of the entrants were graduated four years later; and the class of 1924 graduated 36.4 per cent. gross. Possibly others present may have figures on student-mortality which may confirm or deny the apparent conclusion that the students who are entering the engineering colleges now are not as good as those who entered ten years ago, or else that the course study is tougher and more difficult.

## THE ENGLISH CONFERENCES.

The two conferences on English to be held in connection with the annual meeting of the Society for the Promotion of Engineering Education at Schenectady mark the fourth occasion in which an earnest group of men and women vitally interested in appraising the importance of English in the engineering curriculum and in conferring regarding the problems involved in the teaching of English to engineering students has come together to their mutual profit and satisfaction. It can hardly be claimed that these conferences have settled finally all the questions inherent in the subject. Indeed it has sometimes seemed that more questions have actually been raised than can will be answered in a life-time. But the past conferences have been profitable in two ways: they have brought together men and women teaching English in colleges widely separated geographically and widely divergent in policy,—men and women who in the past have been somewhat isolated in the pioneer work they were doing; and they have also brought into closer and more sympathetic relations the teachers of English and the instructors in engineering and technical subjects. Both these results have had a real significance for engineering education. There has developed a group of teachers who have a professional pride in the fact that they are rendering a service in a rather new field of educational endeavor. This means that in the future it should be possible to attract to this work a much better class of teachers. Moreover the teachers of English and the teachers of professional subjects have discovered that they have a common problem which can only be satisfactorily solved by wholehearted coöperation and a mutual sharing of responsiblity. These two results have surely been worth while.

The English Committee urges the deans and administrative offices of our engineering schools to see to it that wherever

possible some representative of their English work be present at the English conferences at Schenectady. Whether they are members of the S. P. E. E. or not, they should get great profit from contact with other teachers engaged in similar work, and with engineering educators concerned in securing adequate English training for their students. The Committee also cordially invites all who are interested to be present at the conferences, whether they are teachers of English or not.

J. RALEIGH NELSON, *Chairman*,
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# SUMMER PRACTICE COURSES IN SURVEYING AT THE AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS, COLLEGE STATION, TEXAS.

BY BYRON BIRD,

Professor of Structural Engineering.

The Civil Engineering Department of the Agricultural and Mechanical College of Texas gives two summer field practice courses to its students in addition to the work of the regular session. These courses are of approximately three weeks duration. The one is required for men who have successfully completed the Sophomore work, and the other is required after a successful third year in the course in Civil Engineering.

The work following the sophomore year includes adjustment of instruments, observations on Polaris and on the sun for azimuth, base line measurement, leveling, triangulation, boundary survey and computation of area, topographic survey of a portion of the College lands by transit and stadia and also with the use of the plane table.

While all of the above subjects are covered in plane surveying courses, the student does not have sufficient practice work to acquaint him properly with handling surveying equipment. The object of the sophomore summer practice course, therefore, is to teach the student:

(1) Application of theory of plane surveying courses.

(2) Care and use of surveying equipment.

(3) Accuracy in securing field data.

Full working days are spent in the field. Party duties are changed every half day so that each man has a chance to serve as instrument man in his proper turn. Hot lunch is served in the field at noon. The Civil Engineering Department provides wood lunch boxes with metal food containers

designed especially for this purpose. This arrangement is satisfactory, for otherwise time would be lost in returning to the Campus for lunch, or each man would be required to carry his own.

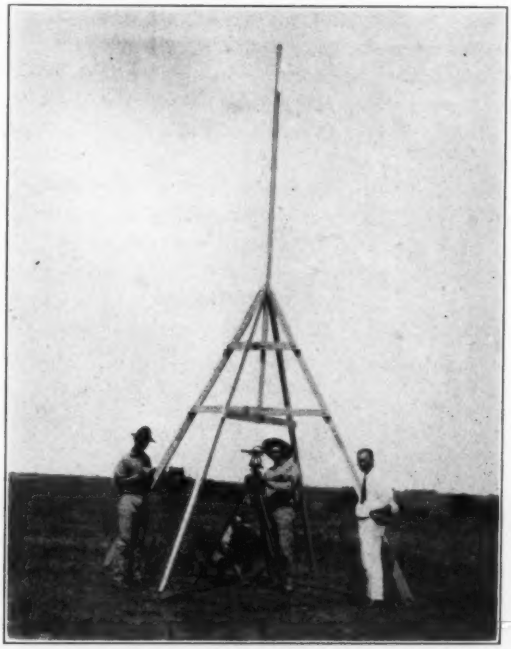

FIG. 1. A Signal Tower.

There are five instructors assigned to this work, four of whom have the duty of direct guidance of groups of the students at different tasks. Upon an older man in the department rests the responsibility of organization, content of the course, the program and general supervision as the work progresses.

The Civil Engineering Department aims to obtain a com-

plete and accurate topographic map of all college property from the results of this work. It is planned to map a new portion each year, or to check up on work previously done in case it is evident that errors exist. The student should, therefore, feel that he is materially assisting in doing something worth while rather than simply solving a set of problems which have been assigned to him.

For the topographic work permanent triangulation points and bench marks have been established over a part of the college lands. Signal towers are used to aid in measuring angles.

The details of the construction of the signal towers can be seen in Fig. 1. The tower with four legs was selected on account of the simplicity of details for the mast connection. The legs and braces are made of 2 x 4 in. material and the staff is 2 x 2 in. The four-legged tower is not as well suited for centering over the point and plumbing of the mast as would be one like the ordinary transit tripod. However, the centering is not such a difficult process after the signal has been set approximately over the point. A slight movement of each pair of legs will bring the center of the staff over the point. The mast is held in a vertical position by three guy wires from the top. The towers are very valuable since they permit the station to be occupied and still not interfere with the work from any of the other stations.

In carrying out this work, high woven wire fences caused considerable trouble at first. The owners were fearful of damage to these fences. To avoid possible trouble in this regard, last year portable stiles were built. These are placed at points where most needed and can be moved as the work proceeds or changes. By the use of these ladder stiles, fences are preserved and the work progresses more rapidly, as no time is lost in hunting for gates or hunting for a suitable place to climb the fence.

The field practice course following the junior year is more advanced and deals with field methods used on highway and

railroad location. It consists of reconnaisance, preliminary and location surveys for a railroad between College Station

FIG. 2. Ladder Stile.

and the Brazos River, a distance of about six miles; survey for a proposed highway along approximately the same line.

There is a rotation of duties in all of the usual operations such as running out the preliminary lines with the transit, leveling, making of land line surveys, drainage area surveys, taking topography, plotting preliminary notes, making paper location, running the located line and cross sectioning.

The students are organized in two groups, each under the direct charge of an instructor. These instructors report directly to the Professor of Railway Engineering, who is responsible for the railway and highway work. Two separate lines are run out with some cross checking, especially in leveling. From the field data at hand a miniature comparison study can be made with regard to a location of a railroad line on the ridge, valley and across country.

The notes which are taken in the field from both courses are used later in the year in drafting room work. Plans and estimates are prepared from the railroad and highway data. Every man is furnished with a set of all notes taken by his section. Loose leaf notebooks are used. The notes are inked daily by a man in the office, and these sheets blue printed. The sophomore notes are used in a course in topographic drawing. In case any of the notes are incomplete or incorrect, the importance of accuracy is at once brought home to the student. He is then sent out to get the required information.

The number of students varies from year to year between sixty and eighty. The cost of the course to each student is about $20.00, which includes laboratory fees and maintenance.

In the past it has not been the practice of the Civil Engineering Department to give credit for these courses for summer work with railway or highway engineering organizations or other work of a similar nature. In a few cases men have taken a special examination when their experience has been such as to warrant giving such an examination, but this procedure has not been encouraged. It is understood that some colleges make a practice of allowing credit for these summer practice courses, providing evidence of the right kind and amount of field work can be furnished.

## ORAL EXAMINATIONS.

BY CHARLES H. CHASE,

Professor of Steam Engineering, Tufts College.

Experience with technical students for some years has led me to believe that oral examinations can be made a valuable part of their training to prepare them to meet conditions not altogether different in their professional work.

We train students with more or less success to study, to delve into records, to reason from results, to make reports requiring time and deliberation, but they will be continually coming up against questions requiring a ready answer, things they ought to know at once, reasonably well.

At such times, they cannot answer in a half completed sentence and expect the questioner to fill in the rest, as is so often done in the classroom. An answer must be made.

This brings up the question of what or how much the student must know to form the spot cash of his knowledge. The reply may be quickly given—fundamentals, and some general and some particular ideas of their application. The comment upon that answer is that it requires a good deal of memory work, to which the reply is immediately ready—where a man's interest is there will his memory be also. He will not usually forget whether he has fifty cents or fifty dollars in his pocket. He comes pretty near knowing.

The old adage that reading makes the full man, writing the exact man and speaking the ready man, still applies. Answering questions suitably requires as a background ability gained through all three regimens with poise and grit besides, and that is what is required of an engineer.

To gain the best results, oral examinations should be followed up by explanation of correct answers at a later meeting of the class, but no intimation of the quality of the answer should be given to the student at the time of examination.

In conducting such an examination, it can be given to advantage in connection with a written examination in a similar subject. The students may be summoned one by one into a side office and the questions propounded and the marks recorded. More than one examiner may be employed if the number of students and the length of the examination period require it.

It is necessary to prepare the list of questions and answers carefully beforehand to avoid confusion. These may be written at the left of the page with columns headed by the names of the students at the right. The question is read without comment or unnecessary inflection and the grade, 1 to 5, say, is immediately recorded when the student comes to a stop or has answered fully enough.

Experience shows that students say beforehand that the examination will be easy but afterward admit it was the hardest kind of an examination that they ever had.

The reaction on the instructor also is generally good. He has an immediate record of what the men can tell at an instant's notice, in a form in which the results may be compared readily with each other. The effect may not always be flattering to the instructor. Some of less brilliant men, of sturdy characteristics, who are not easily disturbed by the unfamiliar form of the examination, often show up to good advantage.

Regarding the influence of the test on the final mark for the subject, that is for the individual instructor to determine, but such an examination is bound to have a good effect on both parties to it.

## THE WRITTEN TEST.

BY GEORGE W. MUNRO,

Professor of Thermodynamics, Purdue University.

A test or written lesson is a pedagogical device having a three-fold purpose.

1. To stimulate the student and to focus his attention on important phases or portions of the work.
2. To secure an objective measure or grading of the student's progress in the work of the class.
3. To enable the instructor to check his material and method against the capacity of his class.

To accomplish the first purpose it is desirable that the time of tests shall be previously announced together with the particular ground to be covered; also that a class review shall point out the important phases of the work covered together with the connections, logical, historical or other; that the student may secure proper perspective.

Focus on important phases and developments in the work can only be obtained when these parts are stressed in class and then systematically followed by question or test.

The benefits which a student will derive from a test will largely depend on his mental attitude toward the instructor and the methods of instruction. A student entering a test with the idea that he is to engage in a game of wits with the instructor will usually play the game on a wits basis. This always obscures relative values in a subject and too often furnishes incentive to dishonest practices in the written work.

The second object; securing an objective grading of the degree of mastery of the subject by the student; depends entirely on the ingenuity and carefulness of the instructor in framing the questions and grading the papers. In preparing questions four points should be remembered;

1. All sections and all students should have questions of the same nature, degree of difficulty, and relative importance in the subject. That is, the standard should be uniform and entirely impersonal.

2. Enough questions should be provided so that complete failure in one does not depress the grade below the passing standard. This for student morale.

3. Questions should be so clearly and concisely stated that only one interpretation is possible. They should be so specific that the answers may at once be evaluated as wholly right, wholly wrong or partly right and partly wrong. Questions of the form "discuss the relation between heat and work" are particularly inappropriate for engineering subjects where training in precision of thought and language is of so great importance.

4. Questions of a grading value aggregating more than a passing grade should be *obviously easy* to answer from information given directly in text or lectures. The student who conscientiously studies and masters the material of his course as presented is certainly entitled to a passing grade and his standing should never be jeopardized by a series of catch questions.

However, questions having a grading value of approximately 20 per cent. may well be made to depend on implications not immediately apparent from the text material. Such questions measure the ability of the student to absorb, reclassify and utilize the information acquired and so serve to distinguish the superior intellect from those of only mediocre grade. In this way the higher grades won may be made to represent real mastery of the work.

Grading papers is an arbitrary process. The instructor is required to set up and maintain in mind a set of standards which must be applied impersonally and rigorously to each paper in turn. These standards can not in fairness be based on absolute right or wrong, nor yet on what the instructor knows of the subject; but rather on what the student at his stage of progress can reasonably be expected to know. These

arbitrary standards are very elusive and difficult to maintain. They are influenced by both the physical and mental states of the instructor; by weariness, impatience and disgust; by hunger, cold and lack of ventilation. In short, anything which depresses the instructor depresses grades.

The class standing of a student is an important thing to him and it should always be treated seriously by the instructor. It constitutes the "coin of the realm" in which payment is made for a vast amount of very real work and anything, whatever, which tends to depreciate or to render unstable the only currency available, very seriously decreases the power of the instructor to secure intellectual effort from the student. To the student it measures his accomplishment against that of his fellows, establishes eligibility to honor societies, procures advancement in his fraternal organization, secures parental satisfaction and support and in general becomes the measure of his success. An "A" grade corresponds to a raise in salary; a tangible appreciation of work well done.

Questions should then be so set and graded that the able man working conscientiously shall be certain of his reward. They should also insure that proper reward shall be meted out to the student, able or otherwise, who is not working conscientiously.

Regarded as a measure of the success of the work of the teacher, the test is most important. When able men acquire non-passing grades something is wrong, and serious investigation is needed and will soon be made. My personal preference is for a place *on* the investigating committee rather than *before* it. With the confidential advance information afforded by his test grades, the instructor should consider with the greatest care the following possible sources of trouble:

(*a*) The instructor; his methods, knowledge of the subject, enthusiasm.

(*b*) The subject; its difficulty, coördination with prerequisites, logical development.

(*c*) The text and other sources of material available to the student.
(*d*) Social and other outside activities demanding student attention.
(*e*) Excessive demand on students by work of other instructors.

Timely consideration of the possible sources of trouble as outlined will usually enable an instructor to effect necessary reforms in his work, or to report upon disturbing outside influences before disaster overtakes the students; the more or less innocent victims of any set of untoward conditions.

In conclusion, the teaching ideal must dominate the test as it does the classroom. It demands that the instructor shall constantly strive to:

(*a*) Develop the thinking powers of all the students.
(*b*) Give every student a working knowledge of the fundamentals of the subject.
(*c*) Stimulate the student's natural curiosity along scientific and cultural lines.

The first demands that each student shall do his own work.

The second, that the instructor shall recognize and emphasize fundamentals rather than details.

The third, that the instructor shall maintain broad contacts with world movements and progress.

While the test grades only measure success in the second, a working knowledge of the fundamentals of the subject, directly; they are yet very directly influenced by the logic and the perspective of both student and instructor.

# ECONOMICAL LEARNING.

BY MORRIS WENK,

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The words, economical learning, that is learning with the least effort in the shortest time, imply that all learning is not done that way and that the time and effort taken can and should be reduced for the benefit of all concerned, the student, the teacher, the school and the public. If we are to practice economy of time and effort in acquiring something it will be well to consider carefully what the thing is—what is learning, the act of learning, how can we do it as easily and quickly as possible, what has been found out about methods for this, how long should one study, what is the rôle of the teacher in the process, how should the student study?

That there is outrageous waste of time and effort in learning all through the whole school system is almost the scandal of the educational world to-day. The grades, the high schools and the colleges are full of it. It is the purpose of this paper to answer somewhat the questions outlined above as to some things that could be done to improve existing conditions.

What is learning?

A distinguished educational psychologist wrote: "The process of learning is one of simple making and keeping connections and readiness in the neurones to conduct, but the result is a mixture of organized and unorganized tendencies that even in an average three-year-old child baffles description and prophecy. Learning is indeed, theoretically and perhaps in fact, possible without any other factors than a situation, an animal whose inner conditions it can change, the retention of certain of these conditions in the animal because they favor and the abandonment of certain others of them because they disturb the life-processes of the neurones concerned at the time."

"All learning is analytical: (1) The stimulus-response situation or bond never leads from absolutely the entire situation or state of affairs at the moment. (2) Within any bond formed there are always minor bonds from parts of the situation to parts of the response each of which has a certain degree of independence so that if that part of the situation occurs in a new context that part of the response has a certain tendency to appear without its old accompaniments."

Stated another way learning is remembering stimulus-response situations where the response made was the one desired from the stimulus applied. In simple scheme this is reception of impressions through the senses, assimilation, analysis and combination from the ends of the neurones through the synapes to the ends of other neurones in the brain or cortex which produce a redirection of impulses to produce a reaction, muscular or mental. The sense organs particularly the eyes and ears must be in good condition.

In other words acquiring knowledge is habit formation and memory since habit is getting one desired response to a given stimulus when several are possible and memory is the accumulation of common elements so that the occurrence of one or more in a situation will reintegrate a previous situation or one very similar and the response previously given. In psychology the chief concept of learning is that of a mental function. Any group of responses may be isolated and considered a mental function. Education may be considered as building up the mental functions in various subjects including morals and ethics.

How can we acquire this complicated thing—learning—education—knowledge—most economically, in the least time with the least effort?

Since Ebbinghaus began in 1885 educators and psychologists have done a great deal of work trying to find the answer to this question. Starch states that the factors affecting progress in learning are:

(*a*) Length and distribution of periods of study.

(*b*) Forgetting.

(*c*) Concentration of effort and zeal.
(*d*) Specific practice in the function to be improved.
(*e*) Definite knowledge of success and error.
(*f*) Interest in improvement.
(*g*) Mental imagery.
(*h*) Fatigue.

The work of Ebbinghaus was to have persons memorize nonsense syllables and find out how long it took to be able to repeat them using different numbers of syllables in the series learned and different arrangements of the length of study per day and days on which to study, viz.: A long period on one day, several short periods on one day, a shorter period on every day for several days or every other day or every two days. He found that short periods of practise distributed over a long time had an advantage over longer periods distributed over shorter time.

Jost comparing ten repetitions a day for three days with thirty repetitions on one day found a saving of fifteen per cent. from the shorter periods. Miss Perkins used seven paired series of nonsense syllables which were presented visually at the rate of one in three seconds with three seconds between. She compared one repetition a day with two, four, and ight repetitions so that each series was presented sixteen times and tested the learning by a repetition test two weeks after the last test. It was found that one repetition a day was the best and eight repetitions on each of two days the poorest. This brought out the point which has been confirmed by Pyle in his laboratory that when a series of nonsense syllables has been presented once, further presentations at the same sitting have less value than the first presentation. After one presentation to get the most value from another, time must elapse.

The following is one set of nonsense syllables used by Lyon in one series of his experiments. Vus, Yif, Miv, Jep, Vob, Feg, Wof, Tib, Nuz, Bof, Jed, Kib, Vel, Zid, Bol, Sef, Yub, Kuf, Tef, Nad. Nonsense syllables rather than meaningful words have been used in one line of investigations as to the

best length of study period and best distribution in order that the association of ideas of the words would not come in and befog the results. With the nonsense syllables it is pure memory work and the results are dependable.

Dearborn, Starch and Pyle used some form of substitution experiment, one of which was to substitute numbers for letters in meaningful sentences. Starch tried four different distributions in using 120 minutes; ten minutes twice a day for six days; twenty minutes once a day for six days; forty minutes every other day for six days and 120 minutes at one sitting. Five-minute records were kept. He found the twenty minute once a day practice the best, ten minutes nearly as good, forty minutes poorer and 120 minutes poorest of all, being only half as good as twenty minutes a day. He summarizes his conclusions as follows: "That in learning to associate numbers with letters it is more economical within limits to shorten the periods of work and to distribute them correspondingly over a given period of time. The most favorable length of period for this work seemed to be between ten and twenty minutes." The curve of these experiments is shown on page 39, Pyle, "The Psychology of Learning."

Pyle in his experiment tried to bring in and measure the differences of learning capacity so as not to vitiate the results. His conclusion is that a thirty minute period is the best length as the second fifteen minutes of practice gives good return but the third fifteen minutes shows a decreasing return. Fifteen minutes is too short, forty-five is too long and the hour shows up poorly, partly because the fatigue of the latter part cuts down the good work of the early part.

He states further: "In habit formation an adult can practice profitably for something like thirty minutes daily. The length of time for practice doubtless varies with individuals and with the state of fixation of the habit. If practice is extended beyond thirty minutes, there may be some return for the extra time but it is relatively small. It is quite probable that in the later stages of habituation the length of practice periods could be shortened and the interval lengthened with

practically as much return. A second practice on the same day is not quite as beneficial as the first one. After a few practices further practice on the same day is useless."

Leuba and Hyde in having students write English words in German script found the second five minutes of a twenty-minute period showing a falling-off from the first five minutes, the third shows improvement and the fourth still further improvement. They found one practice of twenty minutes a a day in the morning better than two a day.

Murphy, in his experiments with normal school girls in javelin-throwing, says that "we conclude that learning periods can be distributed by giving alternate days' practice and even weekly practice without any loss in learning. We believe this to be a conservative statement not only for practice periods involving skill or hand manipulation, but for so-called mental work. We believe we are justified in stating that better work for the amount of time expended can be done in our schools through a distribution of three times a week than through a distribution of five times a week. Learning is a subtraction process to a greater extent than an addition process. The Pauline trouble with all our learners is that it is the things we would not do that overcome the useful things."

Distributed practice is the best but concentrated practice brings good returns and if one is in a hurry to acquire a skill, the diminishing returns for it (concentrated practice) need not be considered prohibitive.

In the class in Advanced Educational Psychology at Harvard Summer School in 1924, eight students undertook an experiment in a substitution of figures for letters as devised by Dearborn. The total time to be used was 120 minutes. Two took it continuously and ten minutes the next day, two worked twenty minutes a day on six days and ten minutes on the seventh day, two worked forty minutes on three days and ten minutes the fourth day, two worked sixty minutes continuous on two days and ten minutes the third day. The results are shown in the table below as worked out by a member of the class.

8 SUBJECTS, TWO ON EACH LENGTH OF PERIOD. AVERAGE PERCENTAGES OF IMPROVEMENT.

| 2 hr. period. | 2–1 hr. period | 3–40 min. period. | 6–20 min. |
|---|---|---|---|
| 96.5 | 107.5 | 149 | 286 |

This limited experiment shows the twenty-minute period once a day as giving the greatest percentage of improvement and therefore the most economical length. No one tried thirty-minute periods. This agrees with more elaborate experiments. With tedious material periods shorter than twenty or thirty minutes have proven economical and even as short as two minutes with children in some school subjects.

Ebbinghaus made curves of progress in learning from his experiments showing graphically the relation of improvement to time using time or its equivalent the number of trials as abscissæ and improvement as ordinates or at least this is a form frequently used. Subsequent investigators have followed him in this and these curves called the learning curves are very interesting to study. The usual form of this curve is asymptoti that is similar to asymptote rising rapidly at first then bending over and as the subject reached the expert stage becoming flat practically parallel to the axis on which time was laid out, any improvement shown by a rise in the curve taking a very long time. That is the curve had negative acceleration. In intellectual learning as in studying history for example the curve has a positive acceleration and is of different form from that of muscular habits.

Bryan and Harter in their classic work on "Studies in the Telegraphic Language" plotted the curves of improvement in sending and receiving messages. Both were of the asymptotic type, the sending curve going up fairly smoothly, but the receiving curve was marked by peculiar flat portions which have been named plateaus followed by rises to a final asymptotic direction parallel to the base from which ordinates were measured. In all learning the easier parts are quickly acquired which accounts for the rapid rise at the beginning as for example learning the easier letters in telegraphing, but

when it comes to the harder letters the progress is slower and the curve flattens.

This flat portion continues for several weeks, a period of incubation it seems to be, until the difficult parts are learned and the elementary part may be said to have reached the automatic stage, when the progress again becomes rapid and the curve bent upward. Sending is much more easily learned than receiving but has a limit of speed which receiving does not seem to have. Messages can be received faster than any one can send them.

These investigators conceived the idea of an hierarchy of habits to account for the progress of their students and the learning curves which hierarchy they described as "(1) There is a certain number of habits which are elementary constituents of all the other habits within the hierarchy. (2) There are habits of a higher order which embracing the lower as elements are themselves in turn elements of higher habits and so on. (3) A habit of any order when thoroughly acquired has physiological and, if conscious, psychological unity. The habits of lower order which are its elements tend to lose themselves in it and it tends to lose itself in habits of higher order as an element therein."

James in his chapters on Habit speaks of filling the chinks as one progresses so that on arrival at expertness many things which took a painful amount of attention to accomplish are now automatic. This is the same as Bryan and Harter, only stated differently.

While Bryan and Harter worked with the telegraph language their investigations and results apply to all learning and the concept of hierarchy of habits singularly fits practical observation.

Closely allied to learning is forgetting and in testing learning, investigators use it to measure the amount learned of the amount studied, the amount acquired by the study. Subtract the amount forgotten from the total amount learned for one perfect recitation or repetition and the remainder is the amount remembered which can be used as an ordinate in the

learning curve. The curve of forgetting is generally of the asymptotic form pointing downward—the reverse of the learning curve—and it finally trails out close to and about parallel with the base line following the law—If the material learned is new material the ratio of what is retained to what is forgotten varies inversely as the logarithm of the time. This was the conclusion reached by Ebbinghaus and there has been no reason found to change it.

Bean gives five factors in explaining the forgetting curve.

1. The rate of forgetting depends on the degree to which the material had been learned before the commencement of the period of forgetting. Over-learning makes forgetting slower.

2. The rate of forgetting depends on the method of learning, *i.e.*, on such matters as the concentration and distribution of practice. Distributed learning makes forgetting slower, concentrated learning makes forgetting faster.

3. The rate of forgetting varies with the kind of performance in habit formation, or the kind of material in intellectual learning. Significant material is forgotten more slowly than meaningless material.

4. The rate of forgetting varies with the method by which forgetting is measured. Bean thinks forgetting is faster if measured by the reproduction method, slower if measured by the relearning method.

5. The rate of forgetting varies with different individuals. To which may be added (*a*) The rate of forgetting varies with the amount learned at one time. (*b*) Fast learners with other factors equal are slow forgetters.

With nonsense syllables as much as 66 per cent. is lost in the first twenty-four hours. On relearning however and waiting twenty-four hours much more is retained than the first time and by frequent repetitions of this alternate relearning and rest practically the entire material is retained. That is, frequent repetition fixes the material in the memory.

Bryan and Harter found that after having attained a rate enough above the main line rate to prevent discharge a teleg-

rapher might go on for years with no improvement from the practice he was having in his daily work. Nothing seemed able to induce him to improve his rate. When, however, he was forced into a place where he had to very greatly increase his speed to hold his position he could and did improve or dropped out entirely.

These authors write: "The ability to take league steps in receiving telegraphic messages, in reading, in addition, in mathematical reasoning and many other fields plainly depends upon the acquisition of league stepping habits. No possible proficiency and rapidity in elementary processes will serve. The learner must come to do with one stroke of attention what now requires half a dozen and presently in one still more inclusive stroke what now requires thirty-six. He must systematize the work to be done and must acquire a system of automatic habits corresponding to the system of tasks. When he has done this he is master of the situation in his field. He can if he chooses deal accurately with minute details. He can swiftly overlook great areas with an accurate sense of what the details involved amount to—indeed with far greater justice to details than is possible for one who knows nothing else. Finally his whole array of habits is swiftly obedient to serve in the solution of new problems. Automatism is not genius but it is the hands and feet of genius."

Universal testimony gives approval to the conclusion of these authors that only by intense effort is improvement made. And learning can be substituted for improvement in this last sentence. It is intense effort which educates, as the author of this paper knows from his own experience.

Wright states his conclusions that

1. The subject accomplished more work when working under the mental stimulus of having a set task to be performed than he did when working without a definite aim.

2. A known impossibility to accomplish the required conditions tends to decrease the subject's total results.

3. The fatigue accompanying work is not so great when the subject is working under the direct stimulus of a definite aim,

notwithstanding the fact that he aims at the same time to produce an increase in his amount of work.

The doctrine of formal discipline or the transfer of training in one study to another does not seem to be proven except for closely related subjects, though Starch says "Practically every investigation shows that improvement in one mental or neural function is accompanied by a greater or lesser amount of modification in other functions. The improvement in the capacity or function trained is probably never accompanied by an equal amount of improvement in other capacities or functions with the possible exception of a few isolated instances whose actuality may be questioned and even then there is not more than twenty or thirty per cent. of transfer to closely allied functions. The improvement spread to other functions diminishes very rapidly in amount as these functions are more and more unlike the function specifically trained."

The author knows several expert pianists who are far from expert on the typewriter and the reverse and many good letterers on mechanical drawings are poor penmen and the reverse.

Since transfer falls down it is necessary for economical learning that there be specific practice in the subject one desires to learn.

The student who has no information as to the success or error of his work labors very much in the dark and is deprived of a very useful stimulus to effort. White in a paper before the Society for the Promotion of Engineering Education at Boulder, Colo., 1924, described a scheme where each student was given a number known only to the teacher and himself. A chart was made showing the several courses and the position of his number on this chart indicated his progress. The student knew where he stood, whether he was falling behind or advancing and the scheme was found very successful in keeping the students up to their best and in not a few cases inspired a man to pull himself up from failure to quite a satisfactory grade.

Arps writes: "From the general character of the curves and the introspective statements it appears that work carried on under conditions of partial awareness of results loses in efficiency and that such conditions are extremely difficult if not impossible to maintain when such work is followed or preceded by work of identical character under conditions of complete awareness. The efficiency under known conditions where they knew the results was ten per cent. better than under unknown conditions."

For economical learning the student must have interest in improvement; he must have the great motive power of all endeavor, "I want." Teaching is very much like the proverb "You can lead a horse to water but you cannot make him drink." Every teacher knows that his chief problem is to get and hold the interest of his students in the subject he is teaching. If it is difficult to learn at all in a state of indifference to the subject, the idea of economical learning under such conditions—acquiring the most in the least time and effort—becomes an idle contradiction in terms. It cannot be done.

Pyle found in his experiments that "those learners who carried on the practice with the highest degree of concentration, that is the most interest in improvement, other factors being equal, made the fastest progress. The fast learner is tense, the whole body seems devoted to the learning process, no other process can participate to any considerable degree in the organism's activities while these particular processes are in progress. In attentive learning the doors seem to be closed—shut against all other processes.

How shall matter we want a student to learn be presented to him? Shall we read it to him or lecture to him or shall he read it in a book or on the blackboard? That is, shall the presentation be visual or auditory or combined? There has been a great deal of discussion as to which is the better method of the three and the outcome has been little more than a drawn battle. Starch thinks the auditory is the better but the individual differences in students make one method of

presentation better for some individuals and the other methods for other students. In the case of the author of this paper he is unable to say whether he learns better by auditory presentation or by visual. In any event the presentation must be, for the benefit of economical learning, made in such a way that the student can quickly visualize the problem from materials in his own experience.

Fatigue is largely a nervous phenomenon and in mental work the nervous system is much more fully involved than it is in physical work.

The brain cells, the synapses, the neurones get tired. When they do, mental effort is made with diminishing returns and diminishing returns are not economical. The muscles get tired as we all know and we can not work as well toward the end of a hard day as we did about the middle of it. The fatigue of muscles is caused by decomposition of the carbohydrates in the tissues and the formation of certain toxic substances, particularly lactic acid, creatin and carbon dioxide, and in extreme fatigue the hemoglobin in the blood is reduced in amount. These poisons seem to lessen the conductivity of the neurones thereby lowering their functioning capacity.

As indicated before in this paper fatigue is an important factor in the best length of study period. One can go on after the first feeling of fatigue, but eventually says: "I am tired out, I cannot study any longer." He may have received some benefit from his study after fatigue began to be felt, but it would have been better, that is, more economical to have stopped then and taken it up again the next day. The feeling of fatigue may come from poor ventilation, keeping too much carbon dioxide in the blood, or it may be, as it frequently is, merely another name for boredom.

Burnham says, "An essential condition for the functioning of the nerve cell and of the nerve fibre is an adequate supply of oxygen. The amount of oxygen needed seems to depend on the number of responses of the nerve cell per second and upon the rate of conductivity in the nerve fibre, *i.e.*, the more efficient the functioning, the more oxygen is needed. When

the amount of oxygen in the air falls below 8 per cent. the brain strikes work—quits. This explains the efficiency of out-door schools."

The remedies are sleep, pure air, and an interest in the subject.

The paper so far has indicated that an intense "I want" is the motive power behind the concentrated effort which educates, that the proper length of study period properly distributed, practice on the specific thing desired to be learned, definite knowledge of success and error, mental imagery and fatigue are important things in economical learning, but what of the human parts, the student and the teacher? Clearly they should not be left out.

How should the student study? Obviously, if the ideas of the paper are correct he should study in a way to carry them out. He can supply the concentrated effort and zeal, the interest in improvement and he can take proper care of his health. He should attend to all physical defects known and be examined for unknown and have them removed or treated, teeth, eyes, ears, nose. He should be careful in his eating but above almost all else, he should get abundant sleep in well-ventilated rooms. Have a convenient place to study, a regular time and when the time comes *study!*

The three types of studying, the reading type, the laboratory type and the reasoning type will require somewhat different methods but the principles are the same.

In intellectual learning, where ideas are connected with ideas and the neural trends for connecting them are established, there is a very great deal of interference and the student must summon all his powers of concentration to get along a road which seems fairly alive with sirens and imps trying to divert him from his goal.

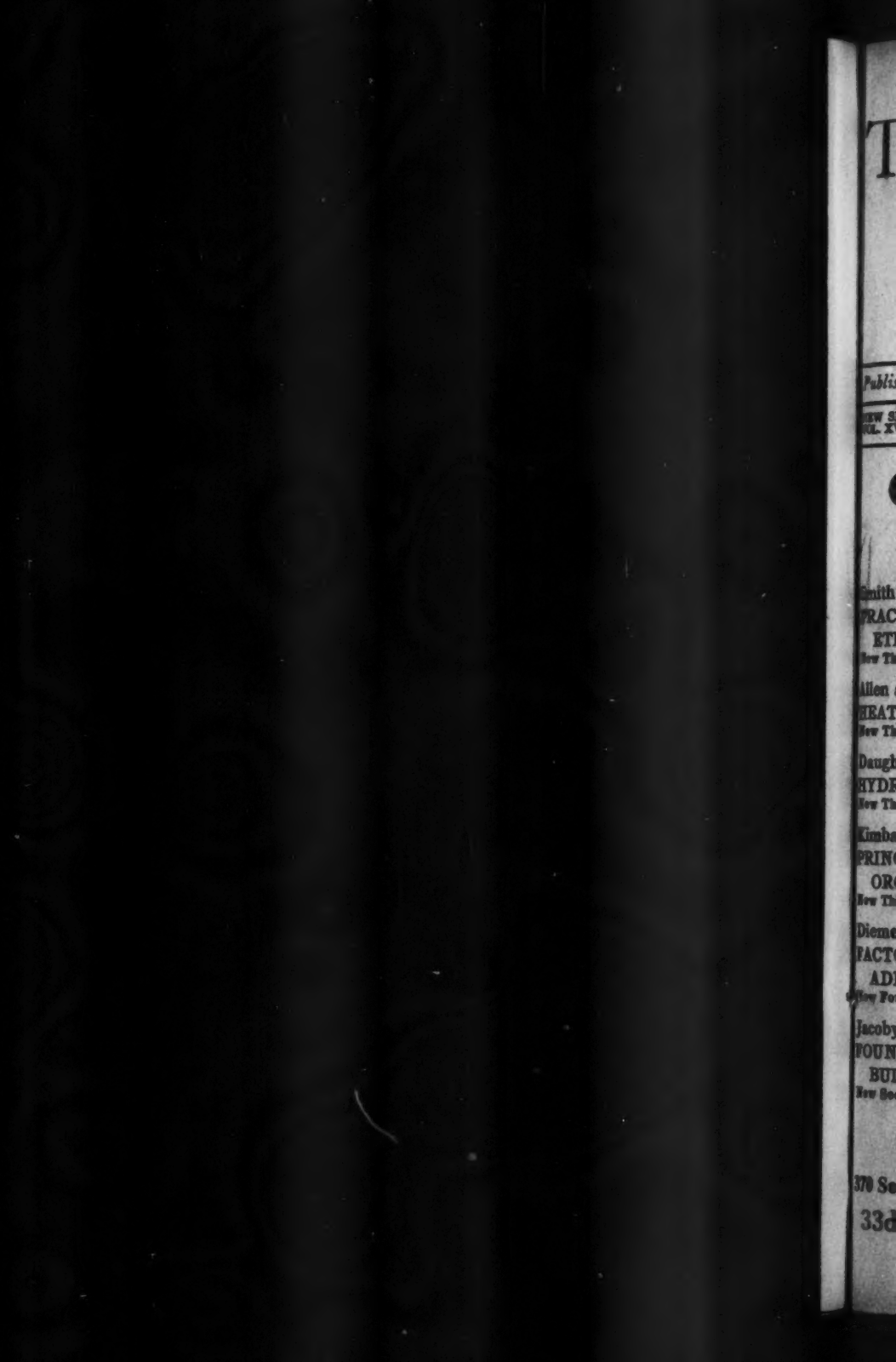
The teacher is usually of a generation older than his pupils and since it is very hard for one generation to get into the spirit of another, the teacher cannot enter into the ideals of his students fully. But the fact that he has gone before, has been over the road or been through the mill, to use collo-

qual phrases, makes him an extremely important factor in economical learning. Any person fit to be a teacher will have a personality which will impress his students that what he tells them is the truth and his statements and directions will be accepted and followed.

The skilful teacher can show the students the correct way of performing a task and insist that the economical method be followed. He knows the difficulties in the course and can recognize when the student is confronted by them and can hint the way to overcome them quickly. He can help them learn how to learn. He can aid in building up the hierarchy of habits by preventing the lingering on of the elemental habits too long. He can demand the better grade of work which forces the student up.

By wise direction and encouragement from the teacher the students gradually acquire the habit of succeeding which brings the pleasure and the satisfaction necessary to a favorable attitude toward the course and interest in it. He can help the students to understand the purpose and nature of the habits to be formed and he can prevent learning being a journey by an unknown road to nobody knows where.

Horne truly says: "My business is not to give a general mental training by means of my subject, for that is not possible, but to give a specific mental training such as my subject affords. . . . Especially I must rely not so much upon the generalized mental habits my subject is mistakenly supposed to form by its discipline as upon the conscious ideals of thought and conduct I am able to instill appropriately in relating my subject to life."



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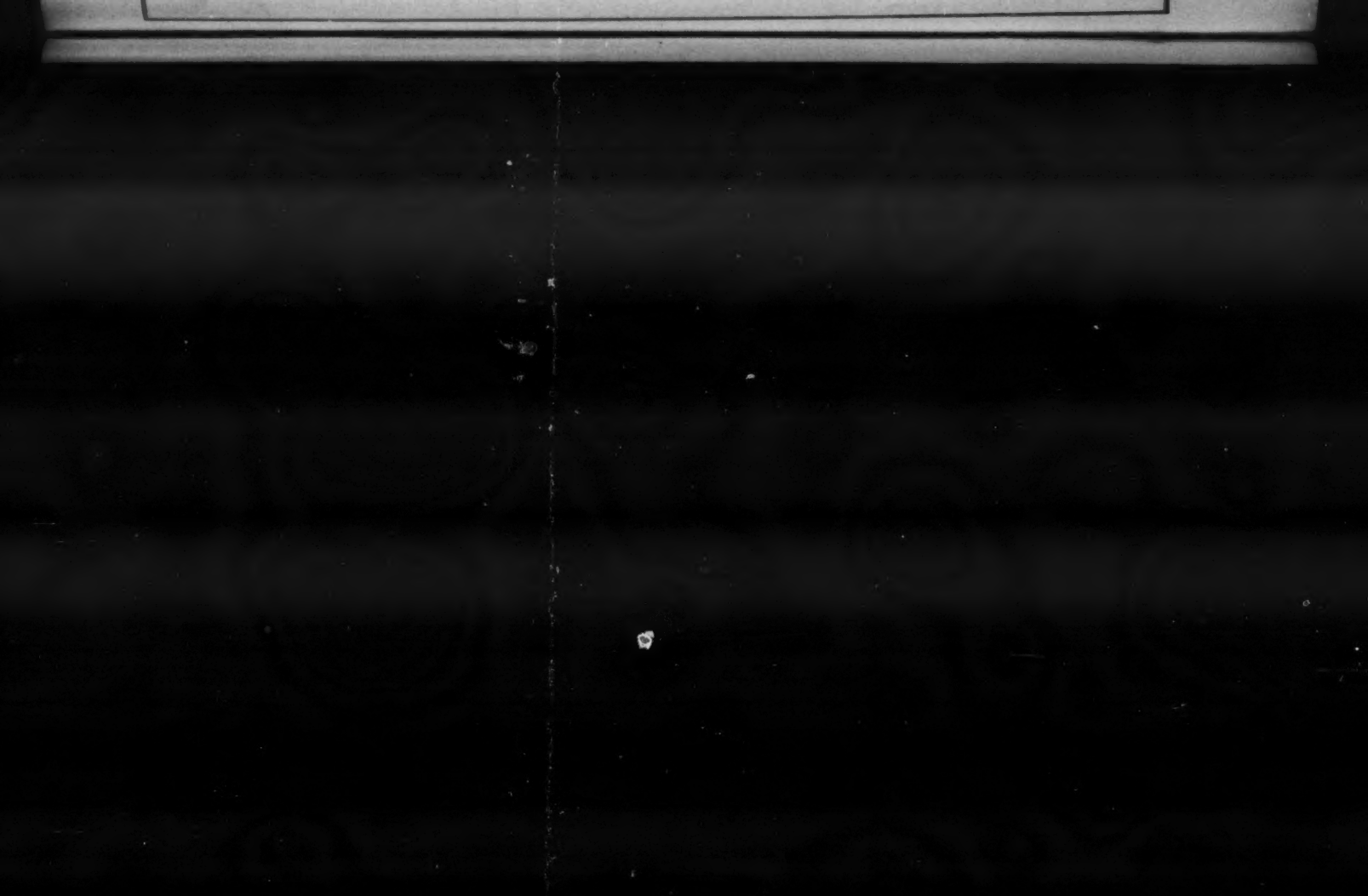

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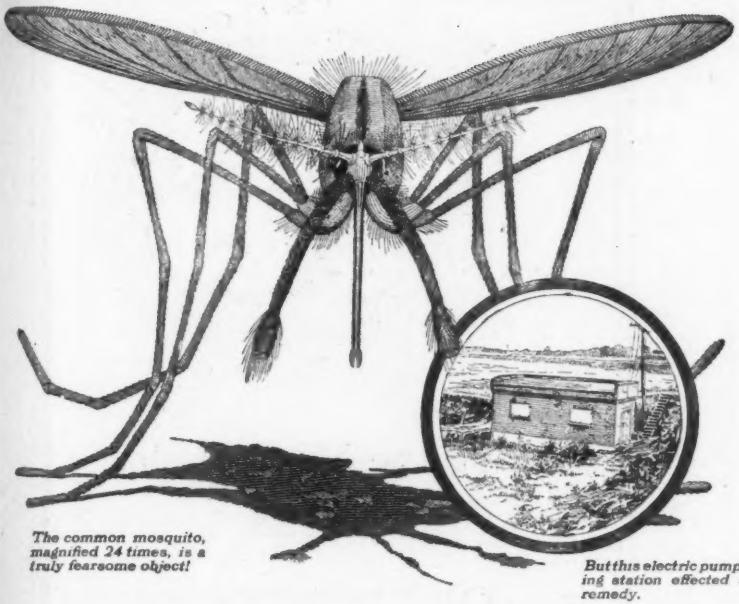

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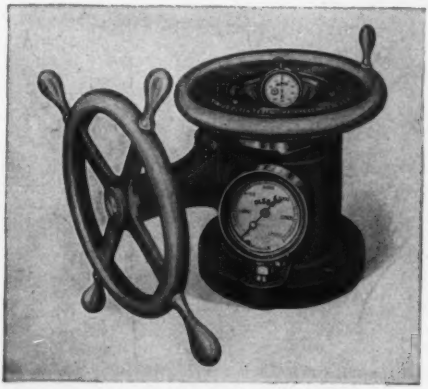

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